

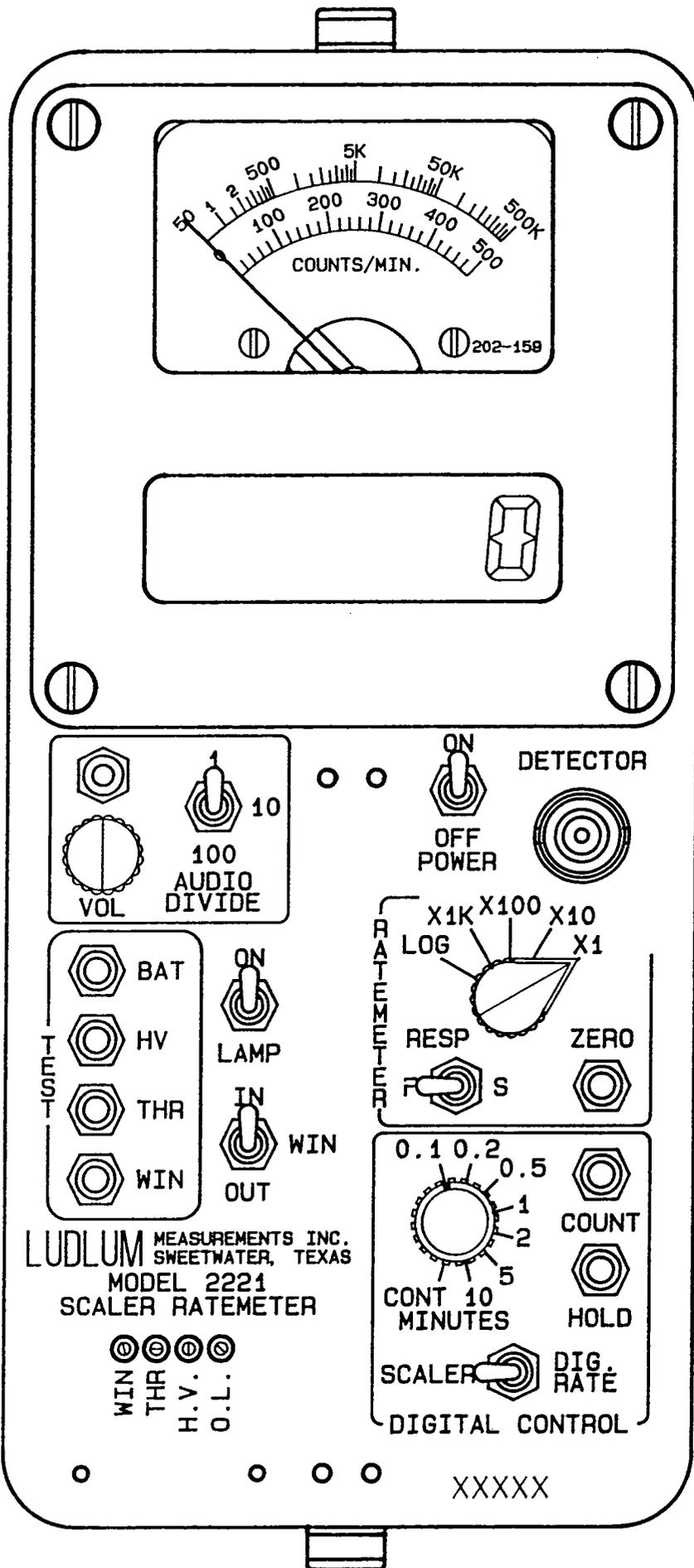
**LUDLUM MODEL 2221
PORTABLE SCALER RATEMETER**

Revised January 2002

**Serial Number 161568 and
Succeeding Serial Numbers**



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January 2002**

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1. GENERAL

The Ludlum Model 2221 Portable Scaler Ratemeter is a self-contained counting instrument designed for operation with scintillation, proportional or G-M detectors. Power is derived from four flashlight batteries.

The unit is complete with a voltage-sensitive preamplifier, linear amplifier, electronic timer, detector high-voltage power supply and detector overload detection circuitry.

A single channel analyzer is also featured in this unit for use in gamma spectrum analysis. The analyzer may be switched on or off, allowing gross or window counting.

The unit has a combination four-decade linear and log ratemeter and a six-digit LCD readout for the scaler and digital ratemeter. Potentiometers are supplied for threshold, window and high-voltage controls.

2. SPECIFICATIONS

- **HIGH VOLTAGE:** 200 to 2400 volts with digital readout

- **BATTERY COMPLEMENT:** four each "D" cell flashlight batteries

- **BATTERY LIFE:** approximately 250 hours with size D, alkaline batteries

- **CALIBRATION STABILITY:** less than 3% variance to battery endpoint

- **SENSITIVITY:** voltage-sensitive and adjustable from 1.5 mV to 100 mV; typically factory-calibrated to 10 mV = 100 on the THR display

- **INPUT IMPEDANCE:** 22k

- **READOUT:** 6 digit liquid crystal display, 0.5" (1.3cm) characters with backlight selection

- **METER:** 2 1/2-inch scale, 1 mA, pivot and jewel suspension

- **SCALES/RANGE:** four decade log ratemeter ranging from 50 to 500k CPM; four decade linear ratemeter - 0-500 CPM meter dial with range multipliers of X1K, X100,

X10, X1 producing an overall range of 0-500k CPM

- **OPERATING TEMPERATURE:** 5-122°F (-15 to 50°C)

- **LINEARITY:** ±10% of the true value for the analog and digital ratemeter; ±2% of the true value for the digital Scaler, HV, THR, and WIN digital voltmeter readings; ±4% of the true value for the BAT voltmeter reading

- **RESPONSE:** 2 positions - Fast response = 4 ±1 second, Slow response = 22 ± 2 second; all response times are measured from 10-90% of final reading

- **CALIBRATION CONTROLS:** recessed screwdriver adjustments with calibration cover

- **AUDIO:** built-in unimorph speaker with click-per-event and switch selectable divide by 1, 10, and 100.

- **CONNECTOR:** Series "C"

- **SIZE:** 4.25" (10.8 cm)W X 10" (25.4cm) L X 9" (22.9cm) H including handle

3. DESCRIPTION OF CONTROLS AND FUNCTIONS

- **POWER:** Two-position switch to turn power to instrument on or off
- **DETECTOR:** series "C" connector for detector

Input Impedance: 22k

Ballast Resistor: 1M

- **RATEMETER:**
 - **F-S RESP Switch:** Two-position switch for selecting ratemeter response: F position 4 ±1 second; S position 22 ±2 seconds.
 - **ZERO:** when pressed, resets the ratemeter

- **RANGE SELECTOR:** Five-position switch labeled LOG, X1K, X100, X10, X1 used to select the analog ratemeter range. The LOG position selects the upper meter scale to provide a four decade logarithmic reading from 50-500k CPM. The X1, X10, X100, and X1K range multipliers used with the lower 0-500 CPM meter scale providing and overall measuring range from 0-500k CPM. Multiply the meter reading by the respective range position.

- **DIGITAL CONTROL:**
 - **COUNT Pushbutton:** When pressed, resets and starts the counter. While the counter is counting, two colons on the display are turned on.
 - **HOLD Pushbutton:** When pressed, stops the counter and leaves the count in the display.

- **SCALER/DIG RATE Toggle Switch:** Two-position toggle switch for selecting scaler or digital ratemeter

SCALER Position: The display shows the counter contents.

DIG. RATE Position: The display shows the ratemeter count rate.

✓ **Note:** The scaler and digital ratemeter are active even when not selected. This allows the user to start a timed count, switch to the Digital Ratemeter and then switch back to Scaler without having to restart the counter.

- **MINUTES Selector Switch:** Eight-position switch used for selecting the count times for the Scaler:

POSITION	COUNT TIME IN MINUTES
0.1	0.1
0.2	0.2
0.5	0.5
1	1
2	2
5	5
10	10
CONT	

COUNTER COUNTS UNTIL HOLD IS PRESSED

- **CALIBRATION CONTROLS:**
 - **WIN:** 20-turn potentiometer used to adjust window width when the window toggle switch, WIN, is in the "IN" position
 - **THR:** 20-turn potentiometer used to adjust the Threshold

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- **HV:** 20-turn potentiometer used to adjust detector voltage
- **O.L.:** 20-turn potentiometer used to adjust detector overload current
- **TEST:**
 - **BAT Pushbutton Switch:** When pressed, displays the battery voltage in the digital display.
 - **HV Pushbutton Switch:** When pressed, displays the detector high voltage in the digital display.
 - **THR Pushbutton Switch:** When pressed, displays the Threshold setting in the digital display.
 - **WIN Pushbutton Switch:** When pressed, displays the window setting in the digital display.
 - **LAMP Toggle Switch:** Two-position switch to turn on the display lights.
 - **WIN Toggle Switch:** Two-position switch for switching the window IN or OUT
 - IN position: The SCA is set up as a window counter.
 - OUT position: The SCA is set up as a gross counter.
- **AUDIO:**
 - **VOL Control:** One-turn potentiometer used to adjust the volume of the speaker or headset.
 - **AUDIO DIVIDE:**
 - “1” Position: provides 1 click per event
 - “10” Position: provides 1 click per 10 events
 - “100” Position: provides 1 click per 100 events
 - **1/8" PHONE JACK:** Used for headset. When headset is plugged in, the unimorph on the can is disabled.
 - **LIQUID CRYSTAL DISPLAY:** Six-1/2" high digits, displaying counter contents or digital count rate
 - **STATUS INDICATORS:**
 - Counter Overflow:** When in SCALER mode, the left digit alternates between the correct digit and an "H".
 - Detector Overload:** The display flashes all dashes.
 - Battery:** When the battery voltage is 4.4 volts or less, all decimal points are turned on.
 - Scaler Counting:** The two colons are turned on when MINUTES selector switch is in CONT position.

4. OPERATING PROCEDURES

4.1 Initial Preparation

- Unscrew battery door latch.
 - Install for "D" size batteries in the battery holder. The correct position of the batteries is indicated on the bottom of the battery door.
 - Switch the POWER ON/OFF switch to the ON position. A random number will first be observed in the display, then 8.8:8.8:8.8. The third displayed number will be the program version. (At the time of this printing, program version is #261010.)
 - Press COUNT pushbutton. The display should zero. Two colons should appear on the display.
 - Press HOLD pushbutton. The colons should disappear.
 - Switch LAMP toggle switch to the ON position. LCD display backlighting and two lamps at the bottom of the analog meter should be illuminated.
- ✓ NOTE: If the Lamp switch is left in the ON position for extended periods of time, battery life will decrease rapidly.
- Check TEST pushbutton functions for proper operation.

4.2 Operating Point

Instrument and detector operating point is established by setting the probe voltage (HV) and instrument sensitivity (THR). For a given detector system, efficiency, background and noise are fixed by the physical makeup of the detector and rarely vary from unit to unit.

However, the selection of the operating point makes a marked difference in the apparent contribution of these three sources of count.

In the singular case of the G-M detector, a minimum operating voltage is required to establish the G-M operating region. (At lower voltages, the detector operates as a very insensitive proportional counter.) This detector is not capable of energy discrimination (pulse-height discrimination). The Threshold (THR) is typically adjusted to 550, with a THR reading of 100 = 10 mV input pulse, for G-M detectors.

For gain sensitive detectors (proportional or scintillation), the most straightforward method of selecting the operating point is to develop a graph, relating count rate to system gain. This relationship is commonly referred to as a plateau or instrument plateau curve. System gain may be changed by adjusting detector high voltage or THR control. The threshold is typically adjusted for 100 = 10 mV for scintillation detectors and 50 (5mV equivalent) on the THR readout for proportional detectors.

4.3 Limitation of Controls

HV Control provides a linear adjustment of the detector voltage supply. The range is approximately 0 to 2400 volts. Changing the detector voltage will cause the detector gain to change. It should be remembered that a linear change in voltage will cause an exponential change in detector gain. THR Control sets the basic pulse discrimination point of the scaler.

WIN Control is calibrated with the THR control so that the reading of the WIN control is equivalent to the reading of the THR control. As an example, 100 on the THR is equal to 100 on the WIN.

5. DETERMINING INSTRUMENT PLATEAU AND SELECTING OPERATING POINT

- Set WIN ON/OFF to OFF.
- Set MINUTES switch to 0.1 minutes.
- Set THR control at 100.
- With detector shielded from source, turn up high voltage control and take a plot of HV versus background count rate until the detector maximum voltage rating is reached. (Maximum voltage on most scintillation detectors is 1500-1600 Vdc; maximum voltage on proportional detectors is reached at the continuous discharge point. Return HV control to minimum.
- Expose the detector to a source and again make a plot of voltage versus count.
- Plot both sets of data and select the operating point to correspond with maximum source count and minimum background count. Avoid areas of very fast count rate changes with small changes in detector voltage. The optimum operating point for low background detectors is just above the inflection point (or break-over point) of the plateau curve. If background count is irrelevant, shift operating point to the plateau center for greater stability.

6. WINDOW OPERATION AND ENERGY CALIBRATION PROCEDURES

- The following procedure calibrates threshold directly in keV.
- Place RATEMETER multiplier switch to LOG position.
- Unscrew and remove CAL cover.
- Press HV pushbutton. The HV should read out on the display directly in volts. While depressing the HV pushbutton, turn HV potentiometer maximum counterclockwise. The HV should be less than 50 volts.
- Depress the THR pushbutton. Turn the THR potentiometer clockwise until 652 displays.
- With WIN IN/OUT switch IN, depress the WIN pushbutton. Turn the WIN potentiometer until 20 appears on the display.
- Switch WIN IN/OUT to OUT.
- Connect the probe and expose to Cs137 source.
- Increase HV (if HV potentiometer is at minimum, it will take approximately 3 turns before any change is indicated). While increasing the HV, observe the log scale of the ratemeter. Increase HV until ratemeter indication occurs.
- Switch WIN IN/OUT switch to IN.
- Turn the HV control until maximum reading occurs on the log scale. Increase HV until reading starts to drop off, then decrease the HV for maximum reading.
- Turn RATEMETER selector switch to the X1K position.
- Press ZERO pushbutton and release. If meter does not read, switch to a lower range until a reading occurs.

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Carefully adjust HV potentiometer until maximum reading is achieved on the range scale. The instrument is now peaked for Cs137 on both the LOG and Linear scales.

✓ NOTE: When the THR control is adjusted, the effective window width remains constant. As an example, if the THR is set at 612, the WIN at 100, a 662 keV peak $612 +$

$(100 \text{ divided by } 2)$ will be centered in the window. Then the threshold point is equivalent to 612 keV with a 100 keV window and calibrated for 100 keV per turn. Now if the threshold is reduced to 250, the threshold is equivalent to 250 keV, but the window (100) is still equal to 100 keV. Proportionally, this represents a broader window.

7. OVERLOAD DETECTION CALIBRATION

■ Detector Count Saturation is detected in this instrument and is indicated by the LCD display flashing all dashes and the analog ratemeter deflecting full scale. The count saturation or "overload" point is calibrated by the O.L. front panel control.

Adjust the O.L. control to fully clockwise position.

Connect detector and set HV for correct detector operating voltage.

Expose detector to radiation field and while observing ratemeter, increase field intensity until a decrease in count rate is noticed. For alpha scintillators, the detector photomultiplier tube (PMT) should be exposed to a small light leak through the probe face to establish the detector saturation point.

With the detector in the count saturation field, adjust the O.L. control counterclockwise until the overload alarm point is reached (flashing dashes in LCD display).

Position detector in a lower field intensity just below the saturation point and confirm overload is defeated.

Example: Ludlum Model 44-9 GM pancake detector saturates at approximately 500 mR/hr (5mS/h).

Full scale instrument analog meter reading = 200 mR/hr (2 mS/h). Set the Model 2221 to overload at 500 mR/hr (5 mS/h) field, then position detector in a 300 mR/hr (3 mS/h) field and confirm that overload alarm is defeated. The O.L. control will have to be "fine adjusted" to perform the above procedure.

8. CALIBRATION

■ Refer to schematic and component layout for the following calibration.

8.1 Ratemeter Calibration

Connect Frequency counter to pin 18 of U22 (80C51FA) on Processor board,

#5261-073. Confirm crystal frequency is 6 MHz $\pm 0.1\%$ (6,006 khz-5,994 kHz).

Set THR control to 100 and Window IN/OUT switch to the OUT position.

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Connect Ludlum Model 500 Pulser or equivalent and adjust count rate for 40,000 CPM.

Switch Ratemeter Multiplier switch to the X100 position and the Response switch to "F."

Adjust pulse amplitude above threshold until a steady count rate is observed on ratemeter.

Adjust R40 Meter Cal (labeled MCAL) on Processor board, for 40,000 CPM on meter.

Switch SCALER/DIG RATE switch to the SCALER position.

Confirm counter time operation by taking 0.1 minute count. Colons should be observed during count cycle.

8.2 TEST Pushbutton/Display Calibration

Adjust THR control to fully clockwise position.

Connect positive voltmeter lead to pin 7 of U3 (TLC27M7IP) on the Amp./P.S. board. Connect negative lead to ground near U3.

Press the THR test pushbutton and adjust R171 Volt Cal (labeled "V"), so that the front panel display reading corresponds to the voltmeter reading at pin 7 of U3.

8.3 High Voltage Calibration

Connect HV meter (2500 Megohm input impedance or greater) to the junction of R32 (4.7 Meg) and R33 (1 Meg) on Amp./P.S. board.

While pressing the HV Test pushbutton, adjust the HV front panel control until the display reads 1500.

Adjust R175 HV Cal on Amp./P.S. board for 1500 \pm 5 volts on external HV meter.

Confirm HV will adjust from 50 to 2400-2500 volts. Insure HV displayed reading tracks within 2% of HV output.

8.4 Threshold/Gain Calibration

Set pulser pulse amplitude to 10mV.

With THR set at 100, on display, fine adjust R174 Gain control (on P.S. board) until ratemeter reads 30,000 CPM with 40,000 CPM from pulser.

Adjust THR control for readings of 200, 300, 400, and 500 to insure the pulser input is 20, 30, 40 and 50mV respectively. Use the 3/4 CPM input setting to discriminate turn on points as in procedure above.

Adjust THR control back to 100.

Switch Window IN/OUT switch to the IN position. Adjust WIN control for 100, 200, 300, 400 and 500 to confirm 20, 30, 40 and 50mV window cut off points.

Set WIN back to 100 and OUT position.

Check the rest of the front panel functions for proper operation.

9. OVERHAUL PROCEDURE

■ The checkout below can be performed with boards in instrument. An extender board (part no. 5261-098) is available if better access to board components is necessary.

9.1 Amplifier/Power Supply Board

□ Connect L.V. power supply to Model 2221 and plug in Amp/P.S. board. (component side to back of instrument).

□ Adjust the WIN, THR and O.L. front panel controls to maximum clockwise position. Turn HV control to maximum counterclockwise position. Switch the lamp switch to the OFF position. Window IN/ OUT switch to the OUT position.

□ Adjust input voltage for approximately +4 Vdc and turn instrument to the ON position. Battery current should be approximately 30 mA or less.

□ Confirm pin 8 of U7 (CA3290A) is equal to or greater than +6.4 Vdc.

□ Increase supply voltage to approximately +5 Vdc and pin 8 of U7 should increase to +9 ±1 Vdc.

□ Check for +5 ±0.15 Vdc at pin 8 of any of the TLC27M7IP's.

□ Check for -6.5 ±0.5 Vdc at pin 4 of any of the same TLC27M7IP's.

□ Connect subminax wire from detector input to Amp/P.S. board.

□ Connect HV meter to detector input and adjust front panel HV control to fully clockwise position.

□ Adjust the HV front panel control to the fully clockwise position. Then adjust R175

HV CAL for approximately 2400-2450 Vdc. Decrease front panel HV control to the fully counterclockwise position and confirm that HV output is 50 volts or less. Then set HV for approximately 1000 Vdc.

□ Connect voltmeter to pin 1 of U3 (TLC27M7IP).

□ With HV output set at approximately 1000 volts adjust R176 Current Cal (labeled "O") for approximately 0.1 Vdc at pin 1 of U3.

□ Connect Overrange Simulator (needs to have a 1000 meg resistor) to detector input and confirm pin 1 of U3 increases to approximately 0.15 ±0.01 Vdc.

□ Connect voltmeter to pin 1 of U2 (LM358) and with Overrange Simulator connected, adjust O.L. control on the front panel counterclockwise until the voltmeter reads approx +0.5 Vdc. Disconnect Simulator and confirm pin 1 of U2 goes above +3 volts.

□ Turn O.L. control to its maximum clockwise position.

□ Connect positive voltmeter lead to pin 7 of U3 (TLC27M7IP) and connect negative lead to ground close to U3.

□ Press the WIN test pushbutton and confirm pin 7 of U3 is approximately 2.7 to 3.8 volts.

□ Press THR test and confirm pin 7 is 1.23 ±0.02 Vdc.

□ Press BAT test pushbutton and confirm pin 7 is approximately 0.5 with supply voltage at +5 Vdc.

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□ With the HV still set at 1000 Vdc, pin 7 of U3 should be approximately 1 ± 0.1 Vdc while pressing the HV test pushbutton.

□ Connect oscilloscope to pin 3 of U5 (LM331) and adjust R171 Volt Cal (labeled "V") for approximately 2 khz (0.5 millisecond period) with the HV pushbutton pressed.

□ Connect voltmeter to pin 7 of U3 and while pressing the THR test pushbutton, adjust THR control for approximately +0.1 Vdc.

□ Switch the Window IN/OUT switch to the IN position. While pressing the WIN test pushbutton, adjust the WIN control for approximately +0.1 Vdc at pin 7 of U3 also. Then switch the Window to the OUT position.

□ Connect oscilloscope to pin 2 of U8 (CA3096).

□ Connect pulser and set pulse amplitude for approximately 10 millivolts. Set CPM to 40,000.

□ Adjust R174 Gain (labeled "G") to maximum clockwise position and confirm positive pulses at pin 2 of U8 are approximately 1 ± 0.1 volt in amplitude.

□ Connect oscilloscope to pin 10 of U105 (CD4098).

□ Adjust R174 Gain until pulses just start to appear at pin 10 of U105. Then adjust pulser amplitude until pulses are clearly visible.

□ Adjust R173 T Pulse (labeled "T") for a 2.5 microsecond positive pulse width at pin 10 of U105.

□ Connect oscilloscope to pin 7 of U105 and adjust R172 Width (labeled "W") for a 3 microsecond negative pulse width.

□ Switch the Window IN/OUT switch to the IN position and verify that the pulses are present at pin 7 of U105 from 10 to 20 mV input pulse amplitude and off above approximately above 20 mV.

□ Switch Window IN/OUT switch to the OUT position and verify the pulses appear above the window limit as in the above step.

□ Battery current should be less than 30 mA with +5 Vdc supply input.

9.2 Processor Board Checkout

■ The procedure below is to be used without the Amp/P.S. board. If the Amp/P.S. board is used, delete the steps containing the signal generator use. Use the pulser for the standard count rate inputs. Window, Threshold, HV and Bat test will display the control setting.

□ Plug in Amp/P.S. Simulator board and connect Signal Generator to jumper wires (black= probe ground).

□ Plug in Processor board, component side toward back of instrument. Connect display ribbon cable.

□ c. Set Signal Generator to square wave function.

Range= 10k and all other switches to the OUT position.

□ Adjust the Freq. Symmetry, Amplitude and D.C. Offset controls to achieve a 5 volt negative pulse with a pulse width of approximately 50 microseconds and a period of approximately 1.2 milliseconds.

□ With supply voltage set at $+5 \pm 0.15$ Vdc, turn instrument ON and observe display= 8.8:8.8:8.8 for approximately 2

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seconds, then 261010 indicating the program number.

Connect Frequency Counter to pin 18 of U22 (80C51FA) and confirm crystal frequency is 6 Mhz $\pm 0.1\%$ (6,006 khz-5,994 khz).

Switch the Scaler/Dig. Rate Switch to the Dig Rate position.

Counts should start accumulating every 2 seconds until approximately 50,000 CPM is observed. (The symmetry control can be fine adjusted until 50,000 CPM is achieved). At this displayed count rate, the low BAT Test indication should be observed, indicated by 5 decimal points across the bottom of the display.

Press BAT Test and display should be 4.1 ± 0.2 .

Press HV and WINDOW = 410 ± 20 . Threshold pushbutton has no effect without Amp/P.S. plugged in.

Switch Ratemeter Response time to F.

Switch Ratemeter multiply to X100.

Adjust R40 Meter Cal, (labeled MCAL), until Ratemeter matches displayed accumulated count (approximately 50,000 CPM).

Decade the Multiplier range on the Signal Generator to correspond to each decade on Rate Multiplier to confirm range switch operation.

Connect Voltmeter to recorder output and confirm R41 RCDR CAL, (labeled RCAL), will adjust from 0 to approximately 3.7 Vdc, with full scale CPM on display and ratemeter. Then set for 1 Vdc to equal full scale meter deflection.

Connect Oscilloscope to pin 9 of U10 (ICM7556) and decade Sweep Generator down to the 1k range.

Switch the Audio Divide switch between the 1, 10, and 100 positions to confirm Audio frequency divides or multiplies by 10, between each position.

Connect Headset or unimorph and confirm volume control operation.

With full scale meter deflection (500), check F/S response time (90% full scale) for 4.5 ± 0.5 seconds and 22 ± 2 seconds respectively.

Check Count, Hold, and Zero pushbutton functions.

Switch Scaler/Dig. Rate switch to the Scaler position and check the 0.1, 0.2 and 2 minute time multipliers for correct time operation.

With +5 volts supply input, battery current should be less than approximately 15 mA, with full scale meter deflection.

9.3 Functional/Chassis Checkout

This procedure requires a checked-out Amp/P.S. board and Processor board.

Connect one lead of an ohmmeter to chassis ground.

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Connect other lead of ohmmeter to the Processor board cinch connector pins below to check count time switch operation. Boards are not plugged in yet.

1 = open

0 = shorted

COUNT TIME POSITION	PROCESSOR BOARD CINCH CONNECTOR		
	PIN 8	30	31
0.1	0	0	0
0.2	0	0	1
0.5	1	0	0
1	1	0	1
2	0	1	0
5	0	1	1
10	1	1	0
CONT	1	1	1

Connect external power supply and set input voltage for approximately +5 Vdc.

Turn Lamp switch to the OFF position. THR and O.L. controls to maximum clockwise position and HV to maximum counterclockwise position.

Plug in Processor and Amp/P.S. boards and related cable connections.

Turn instrument ON. Current draw should be less than 45 mA.

Confirm display reads 8.8:8.8:8.8 for approximately 2 seconds, then 261010 indicating the program version.

Connect positive voltmeter lead to pin 7 of U3 (TLC27M7IP) on the Amp./P.S. board. Connect negative lead to ground near U3.

With the THR control full clockwise, press the THR test pushbutton and adjust R171 Volt Cal (labeled "V"), so that the front panel display reading corresponds to the voltmeter reading at pin 7 of U3.

Connect HV meter (2500 Megohm input impedance or greater) to the junction of R32 (4.7 Meg) and R33 (1 Meg) on P.S. board.

While pressing the HV Test pushbutton, adjust HV control until the display reads 1500. R176 Current Cal may have to be adjusted counterclockwise to defeat the Overrange function.

Adjust R175 HV Cal on Amp/P.S. board for 1500 ±5 on external HV meter.

Confirm HV will adjust from 50 to 2400-2500 volts. Insure HV displayed reading tracks within 2% of HV output.

Adjust HV for approximately 1000 volts.

Adjust R176 Current Cal (labeled "0") for approximately 0.1 volt at pin 1 of U3 (TLC27M7IP) on Amp/P.S. board.

Connect Overrange Simulator (1000 megohm) to the detector input.

Adjust the O.L. control counterclockwise until hyphens start flashing across display every other count interval. Disconnect Overrange Simulator and confirm overrange function is defeated. Then adjust to fully clockwise position.

Set THR control to 100 and Window IN/OUT switch to the OUT position.

Connect pulser and adjust count rate for 40,000 CPM.

Switch Ratemeter Multiplier switch to the X100 position and the Response switch to "F."

Adjust pulse amplitude above threshold until a steady count rate is observed on ratemeter.

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- Adjust R40 Meter Cal (labeled MCAL) on Processor board, for 400 CPM on meter.
- Adjust pulser for 10,000 CPM and check meter for $\pm 10\%$ linearity of reading. Adjust pulser and rate Multiplier switch to confirm linear readings on all ranges.
- Switch SCALER/DIG. RATE switch to the SCALER position.
- Confirm count time switch operation by taking a 0.1 minute and 0.5 minute count. Colons should be observed during count cycle.
- Check HOLD and ZERO pushbutton functions.
- Switch SCALER/DIG. RATE switch to the DIG. RATE position and confirm update count display operation approximately every 2 seconds.
- Connect unimorph and headset to the audio outputs and confirm audio divide and volume control functions. NOTE: Unimorph should shut off when headset is connected.
- With the THR control adjusted for 100, adjust R174 Gain (labeled G) for 1.5 millivolt input sensitivity. Insure instrument functions at low input sensitivity without "noise".
- Instrument may have to be placed in can to permit "noise free" operation.
- Set pulser pulse amplitude to 10mV.
- With THR still set at 100, fine adjust R174 Gain control until ratemeter reads 30,000 CPM with 40,000 CPM from pulser.
- Adjust THR control for readings of 200, 300, 400, and 500 to insure the pulser input is 20, 30, 40 and 50mV respectively. Use the 3/4 CPM input setting to discriminate turn on points as in procedure above.
- Adjust THR control back to 100.
- Switch Window IN/OUT switch to the IN position. Adjust WIN control for 100, 200, 300, 400 and 500 to confirm 20, 30, 40 and 50mV window cut off points.
- Set WIN back to 100 and OUT position for instrument shipment.
- Input a full-scale ratemeter count rate (500 CPM) and connect voltmeter to the recorder output. Adjust R41 (labeled RCAL) on Processor board for 1 volt.
- Check F/S ratemeter response time for 4.5 ± 0.5 and 22 ± 2 seconds at 90% of full scale.
- Decrease input supply voltage until periods are observed at bottom of display. Press BAT Test pushbutton and confirm low BAT Test is 4.4 ± 0.1 Vdc. Adjust supply voltage back to 5 volts and confirm BAT test and actual supply input is 5 ± 0.05 Vdc.
- Switch SCALER/DIG. RATE switch to the SCALER position. Count Time Multiplier to CONT. Press count pushbutton and start with low enough count rate to observe each digit number count sequence from Least significant digit to MSD. Decade pulser count rate to speed up digit segment display check.
- Increase count rate enough to overflow counter. An "H" should be observed in the MSD flashing every count interval.
- Turn Lamp switch to the ON position and confirm 2 lamps in the display and 2 lamps below the meter are illuminated.
- Current draw with lamps on should be 210 ± 20 mA.
- Turn lamp OFF and current should be approximately 40 ± 5 mA.

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PARTS LIST

Ref. No.	Description	Part No.	Ref. No.	Description	Part No.
Model 2221 Portable Scaler Ratemeter			C154	0.0015μF, 3kV, C	04-5518
			C164	0.1μF, 100V, C	04-5521
UNIT	Completely Assembled Model 2221 Portable Scaler Ratemeter	48-2065	C165	0.1μF, 100V, C	04-5521
Amplifier/Power Supply Board, Drawing 261 X 56			• TRANSISTORS		
			Q142	2N3904	05-5755
			Q143	MPSU51	05-5765
BOARD	Assembled Board	5261-072	• INTEGRATED CIRCUITS		
• CAPACITORS			U1	TLC27M7	06-6248
C107	1μF, 35V, DT	04-5575	U2	LM358	06-6024
C108	2.2μF, 25V, DT	04-5559	U3	TLC27M7	06-6248
C109	4.7μF, 10V, DT	04-5578	U4	TLC27M7	06-6248
C110	4.7μF, 10V, DT	04-5578	U5	LM331	06-6156
C111	100μF, 10V, DT	04-5576	U6	LM2578	06-6223
C112	4.7μF, 10V, DT	04-5578	U7	CA3290AE	06-6140
C114	10pF, 100V, C	04-5573	U8	CA3096	06-6023
C115	0.1μF, 100V, C	04-5521	U9	CA3096	06-6023
C116	0.1μF, 100V, C	04-5521	U105	CD4098	06-6066
C117	0.1μF, 100V, C	04-5521	U106	CA3096	06-6023
C118	0.1μF, 100V, C	04-5521	U144	CD4052	06-6141
C120	0.0022μF, 100V, P	04-5580	• DIODES		
C121	0.001μF, 100V, C	04-5519	CR10	IN5819	07-6306
C122	0.1μF, 100V, C	04-5521	CR12	MR-250-2	07-6266
C123	100pF, 100V, C	04-5527	CR13	MR-250-2	07-6266
C124	0.1μF, 100V, C	04-5521	CR14	MR-250-2	07-6266
C125	0.01μF, 100V, C	04-5523	CR15	MR-250-2	07-6266
C126	47pF, 100V, C	04-5533	CR16	1N4148	07-6272
C127	0.1μF, 100V, C	04-5521	CR17	1N4148	07-6272
C128	47pF, 100V, C	04-5533	CR18	1N4148	07-6272
C129	100pF, 100V, C	04-5527	CR19	1N4148	07-6272
C130	10pF, 100V, C	04-5573	CR20	1N4148	07-6272
C131	0.1μF, 100V, C	04-5521	CR21	1N4148	07-6272
C132	10pF, 100V, C	04-5573	CR22	1N4148	07-6272
C133	0.0015μF, 3kV, C	04-5518	CR24	1N5819	07-6306
C135	0.0015μF, 3kV, C	04-5518	CR25	1N5819	07-6306
C136	0.0015μF, 3kV, C	04-5518	CR151	MR-250-2	07-6266
C137	100pF, 3kV, C	04-5532	CR177	1N5252	07-6265
C138	100pF, 3kV, C	04-5532	• RESISTORS		
C139	0.0056μF, 3kV, C	04-5522	R32	4.7M	10-7030
C140	0.0056μF, 3kV, C	04-5522	R33	1M	10-7028
C141	0.0056μF, 3kV, C	04-5522	R34	1M	10-7028
C145	1μF, 35V, DT	04-5575	R35	1G	12-7686
C146	100μF, 10V, DT	04-5576	R36	1G	12-7686
C147	100μF, 10V, DT	04-5576	R37	0.1 OHM, 1%	12-7647
C148	10μF, 20V, DT	04-5592			

**M2221 Portable Scaler Ratemeter
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Ref. No.	Description	Part No.	Ref. No.	Description	Part No.
R38	10k	12-7748	R96	1M, 1%	12-7763
R39	1M, 1%	12-7763	R97	10M	12-7749
R40	10k	12-7748	R98	1M	12-7751
R41	10k	12-7748	R99	470k	12-7757
R42	10k	12-7748	R100	470k	12-7757
R43	10k	12-7748	R101	100k	12-7747
R44	47k	12-7758	R102	1M, 1%	12-7763
R45	4.7k	12-7755	R171	10k TRIMMER	09-6822
R46	10k	12-7748	R172	100k TRIMMER	09-6823
R47	10k	12-7748	R173	100k TRIMMER	09-6823
R48	10k	12-7748	R174	10k TRIMMER	09-6822
R49	1k	12-7750	R175	1M TRIMMER	09-6828
R50	220 OHM	12-7753	R176	1M TRIMMER	09-6828
R51	220 OHM	12-7753			
R52	470k	12-7757		• TRANSFORMERS	
R53	47k	12-7758	T103	M2300 HVPS	4275-037
R54	1k	12-7750	T104	M2221 LVPS	4275-094
R55	10k	12-7748			
R56	4.7k	12-7755		• MISCELLANEOUS	
R57	10k	12-7748	9 EA.	CLOVERLEAF RECEPTACLES	
R58	10k	12-7748		011-6809-00	18-8771
R59	10k	12-7748	3 EA.	SPACERS	18-8933
R60	1k	12-7750	*	TRANSISTOR SPACER	18-8992
R61	178k, 1%	12-7769	*	AMPLIFIER SHIELD	7261-100
R62	4.7k	12-7755			
R63	100k	12-7747			
R64	10k	12-7748			
R65	10k, 1%	12-7764		Processor Board, Drawing 261 X 91	
R66	220 OHM	12-7753			
R68	10k	12-7748	BOARD	Assembled Board	5261-136
R69	1.5k	12-7773			
R70	100k, 1%	12-7765		• CAPACITORS	
R71	200k	12-7752	C1	47pF, 100V, C	04-5533
R72	200k	12-7752	C2	0.047μF, 100V, C	04-5565
R73	100k	12-7747	C3	0.001μF, 100V, C	04-5519
R74	100k	12-7747	C4	27pF, 100V, C	04-5614
R78	22k	12-7754	C5	27pF, 100V, C	04-5614
R79	10k	12-7748	C6	22μF, 15V, DT	04-5579
R80	10k	12-7748	C7	10μF, 20V, DT	04-5592
R81	100k	12-7557	C8	100μF, 10V, DT	04-5576
R82	200k	12-7752	C9	100μF, 10V, DT	04-5576
R83	22k	12-7754			
R84	10k	12-7748		• TRANSISTOR	
R85	1M	12-7763	Q36	2N3904	05-5755
R86	4.42k	12-7760			
R87	47 OHM	12-7756		• INTEGRATED CIRCUITS	
R88	100k, 1%	12-7765	U10	ICM7556	06-6244
R89	17.8k	12-7759	U11	CD74HCO8	06-6222
R90	10k, 1%	12-7764	U13	CD4054	06-6245
R91	1M, 1%	12-7763	U14	CD4056	06-6095
R92	1M, 1%	12-7763	U15	CD4056	06-6095
R93	40.2k, 1%	12-7761	U16	CD4056	06-6095
R94	100 OHM	12-7746			
R95	10k	12-7748			

**M2221 Portable Scaler Ratemeter
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Ref. No.	Description	Part No.	Ref. No.	Description	Part No.
U17	CD4056	06-6095	Calibration Board, Drawing 261 X 59		
U18	CD4056	06-6095	<hr/>		
U19	CD4056	06-6095	BOARD	Assembled Board	5261-075
U20	CD74HC573	06-6093	• VOLTAGE REFERENCES		
U21	87C257	06-6278	U1	LM385Z-1.2	05-5808
U22	80C51FA	06-6236	U2	LM385Z-1.2	05-5808
U25	RDD104	06-6060	U3	LM385Z-1.2	05-5808
U26	LM358	06-6024	• RESISTORS		
U43	CD74HC238	06-6246	R4	22k	12-7754
• DIODE			R10	22k	12-7754
CR45	1N4148	07-6272	R11	100k TRIMMER	09-6813
• RESISTORS			R12	100k TRIMMER	09-6813
R27	3.3k	10-7013	R13	100k TRIMMER	09-6813
R28	220k	10-7066	R14	100k TRIMMER	09-6813
R29	130k	10-7067	• CONNECTOR		
R30	470k	10-7026	P6/1-7	640457-7 MTA100	13-8183
R31	220k	10-7066	LCD Display Board, Drawing 261 X 58		
R32	1.2k	10-7058	BOARD	Assembled Board	5261-074
R33	5.6k	10-7042	• INTEGRATED CIRCUIT		
R40	1M TRIMMER	09-6828	U7	3918	07-6252
R41	1M TRIMMER	09-6828	• RESISTORS		
• RESISTOR NETWORKS			R4	22 OHM	10-7072
R34-R35	NETWORK-22k SIP 10 PIN	12-7566	R14	22 OHM	10-7072
• TRANSFORMER			• CONNECTORS		
T37	M300-9	4275-074	P4	RIBBON-RD67	
• CRYSTAL				50BRN EDGE 50P	13-7816
Y39	6.000 MHZ	01-5209	P5	640456-2 MTA100	13-8073
• CONNECTOR			• MISCELLANEOUS		
P3/1-50	RIBBON-1-102159-0	13-7834	DS10-DS13	BULB-#6833	22-9613
• MISCELLANEOUS					
*	28P SOCKET	06-6096			
7 EA.	SPACER-816-045 16P	18-8990			
*	SPACER-470-015	18-8991			
2 EA.	RIBBON-102312-2 LATCH	13-7805			

**M2221 Portable Scaler Ratemeter
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Ref. No.	Description	Part No.	Ref. No.	Description	Part No.
<u>Backplane Board, Drawing 261 X 60</u>			<u>Chassis Wiring Diagram, Drawing 261 X 61</u>		
BOARD	Assembled Backplane Board	5261-076	• AUDIO		
			DS1	UNIMORPH 60690	21-9251
			• CONNECTORS		
CR6	1N5819	07-6306	J1	CONN-640456-2 MTA100	13-8073
			J2	UG706/U SERIES C	13-7751
			J5	PHONE JACK TINI #42A	21-9333
			J6-J7	(ON CAL HARNESS)	8261-088
			J8	(ON MAIN HARNESS)	8261-087
			J9	(ON BATTERY HARNESS)	8261-089
J1-J2	EZA22DRSN	13-8181	J10	NOT USED	
P7	640456-7 MTA100	13-8115	J11	(ON MAIN HARNESS)	8261-087
P8	1-640456-4 MTA100	13-8141	• SWITCHES		
P9	640456-5 MTA100	13-8057	S1-S7	30-1-PB GRAYHILL	08-6517
P10	640456-2 MTA100	13-8073	S8-S12	7101-SYZ-QE TOGGLE	08-6511
P11	1-640456-4 MTA100	13-8141	SW1	513381	08-6656
			SW2	513381	08-6656
			SW3	MTA-206PA	08-6657
			• BATTERY		
			B1-B4	1.5 VOLT "D" DURACELL	21-9313
			• RESISTORS		
			R1	10k NON-LOCKING	09-6753
			• MISCELLANEOUS		
			M1	M2221 METER ASSY.	4261-091

**M2221 Portable Scaler Ratemeter
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DRAWINGS AND DIAGRAMS

Amplifier/Power Supply Board Schematic, Drawing 261 x 56
Amplifier/Power Supply Board Component Layout, Drawing BS261072

Processor Board Schematic, Drawing 261 x 91
Processor Board Component Layout, Drawing 261 x 103

Calibration Board Schematic, Drawing 261 x 59
Calibration Board Component Layout, Drawing BS261075

LED Display Board Schematic, Drawing 261 x 58
LED Display Board Component Layout, Drawing BS261074

Backplane Board Schematic, Drawing 261 x 60
Backplane Board Component Layout, Drawing BS261076

RS-232 Board Schematic, Drawing 261 x 179
RS-232 Board Component Layout, Drawing 261 x 180

Wiring Diagram, Drawing 261 x 61

**M2221 Portable Scaler Ratemeter
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Model 2221 RS-232 Port Addition (LMI Part Number 4261-148)

The Model 2221 RS-232 port addition allows the M2221 data to be read as output to a computer or serial printer, by dumping either the ratemeter or scaler reading, as desired. The desired reading is selected with a toggle switch located in the digital control section of the front panel, labeled with two positions: "SCALER" and "DIG. RATE." The port addition kit (LMI Part Number 4261-148) includes the internal board, a cable that will connect directly to a 9-pin PC port and software routines to log the readings.

The scaler reading dumps when the scaler has completed a count. The ratemeter is dumped every 2 seconds in one of three formats, depending on the firmware installed. The three available formats are (1) counts per 2 seconds, (2) counts per 60 seconds (cpm), or (3) counts per second (cps). Data output is always in a 6-digit format with a letter prefix, corresponding to the following:

Ratemeter: "R"

Scaler: According to the table below

Letter Prefix	Time of Count (min)	Time of Count (sec)
	Format 1 or 2	Format 3 (cps version)
A	0.1	1
B	0.2	2
C	0.5	5
D	1.0	10
E	2.0	30
F	5.0	60
G	10.0	120

A carriage return and then a linefeed character follow the 6th digit.

The communication protocol is 9600 baud, no parity, 1 stop bit, and 8 data bits. The RS-232 port is an output only with no handshaking available. The M2221 will dump the data, no matter what, even if the attached computer or printer is not ready. The cable provided is a coaxial cable, providing TXD and GND to a 9-pin D-connector, ready to plug into a standard PC serial port.

The Model 2221 Processor Board (Part Number 5261-136) utilizes an 87C257 EPROM with one of the following firmware numbers, depending on the desired rate:

Rate Dump as counts per 2 seconds -- #261-06-N03.

Rate Dump as counts per 60 seconds -- #261-07-N02.

Rate Dump as counts per second with meterface 202-930 -- #261-02-N02

**M2221 Portable Scaler Ratemeter
January 2002**

Ref. No.	Description	Part No.
<u>RS-232 Board, Drawing 261 X 179</u>		
BOARD	Assembled RS-232 Board	5261-179

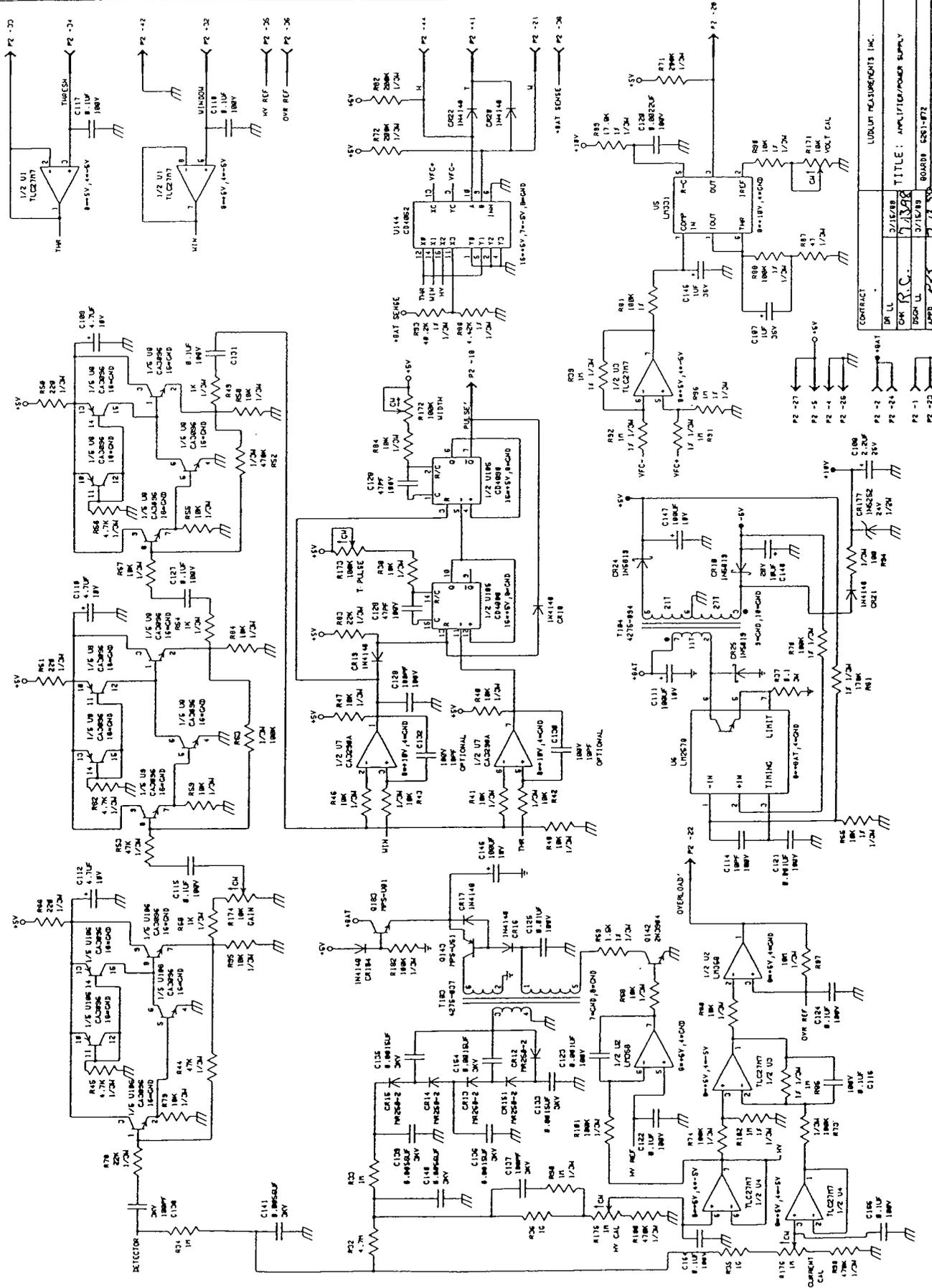
• **CAPACITORS**

C1	4.7 μ F, 20V, SMT	04-5653
C2	10 μ F, 20V, SMT	04-5655
C3	4.7 μ F, 20V, SMT	04-5653
C4	10 μ F, 20V, SMT	04-5655
C5-C6	68 μ F, 10V, SMT	04-5654

• **INTEGRATED CIRCUITS**

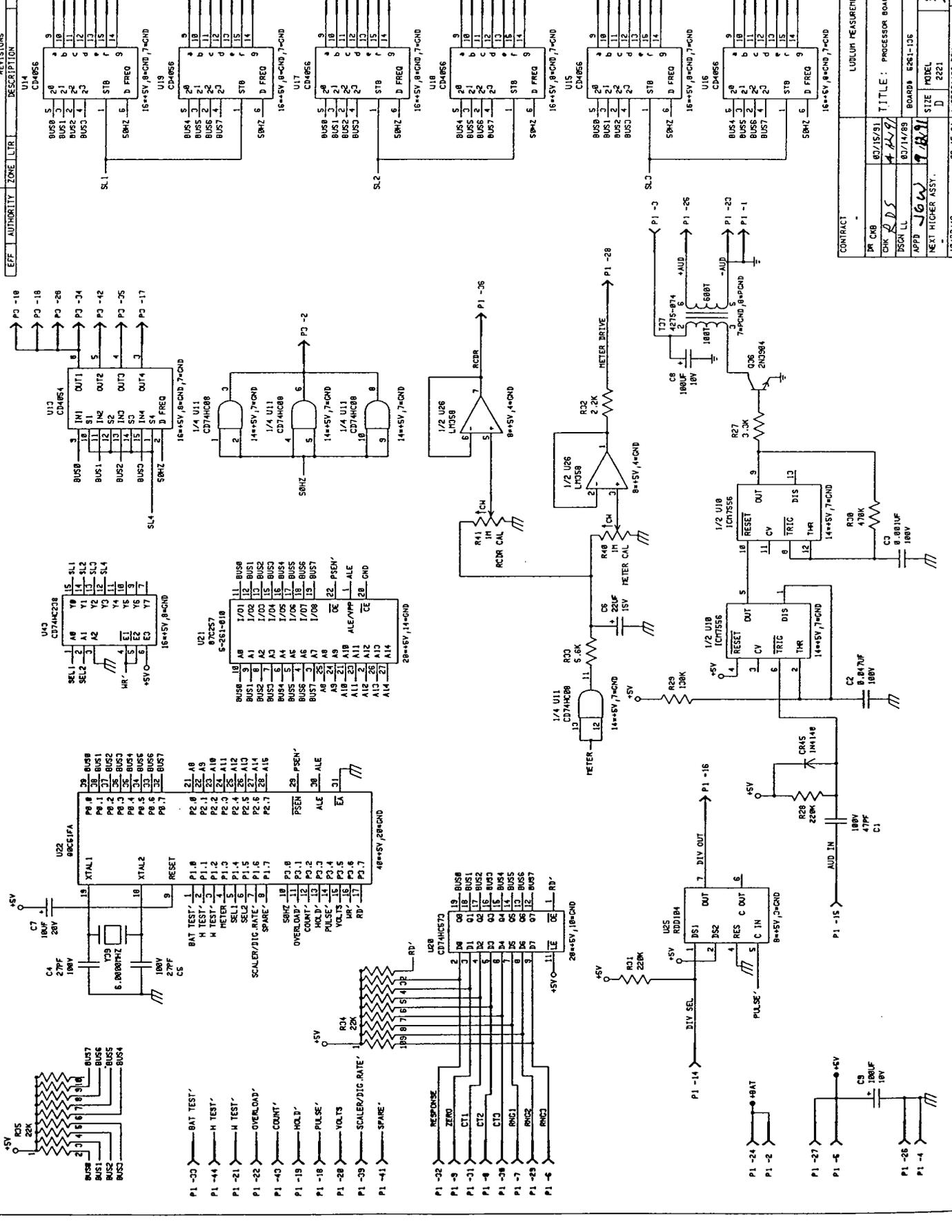
U001	IC-MAX220CSE, SMT	06-6329
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REV.	DESCRIPTION	DATE	APPROVED
1	INITIAL DESIGN	3/15/88	[Signature]
2	REVISED FOR MANUFACTURE	3/15/88	[Signature]
3	REVISED FOR MANUFACTURE	3/15/88	[Signature]
4	REVISED FOR MANUFACTURE	3/15/88	[Signature]
5	REVISED FOR MANUFACTURE	3/15/88	[Signature]
6	REVISED FOR MANUFACTURE	3/15/88	[Signature]
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10	REVISED FOR MANUFACTURE	3/15/88	[Signature]

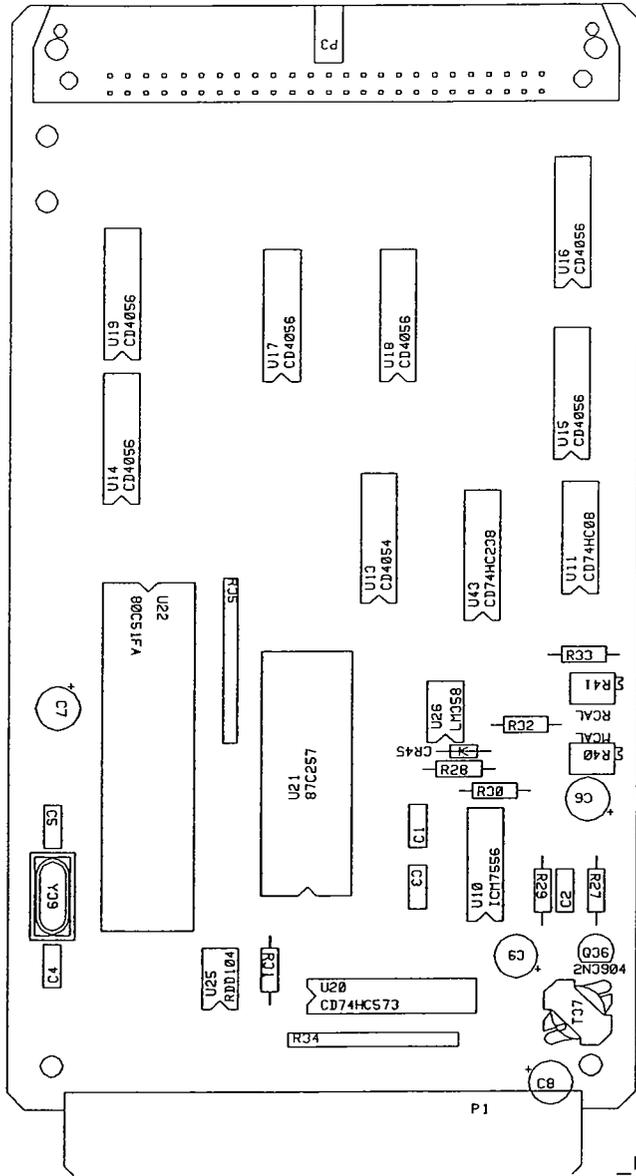


DR. U.L.	3/15/88
DR. R.C.	3/15/88
DR. P.L.	3/15/88
APP. [Signature]	3/15/88
REV. [Signature]	3/15/88
DATE	2/6/86
SHEET	56

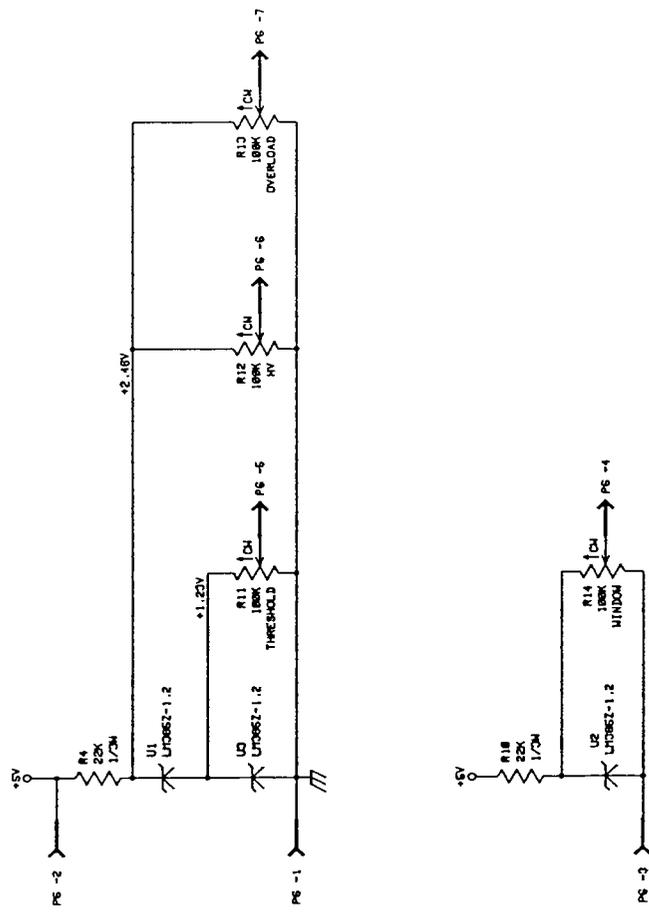
CONTRACT _____
 TITLE: AMPLIFIER POWER SUPPLY
 BOARD: 681-P2
 MODEL: 221
 PART: 221
 LUDLUT MEASUREMENTS, INC.



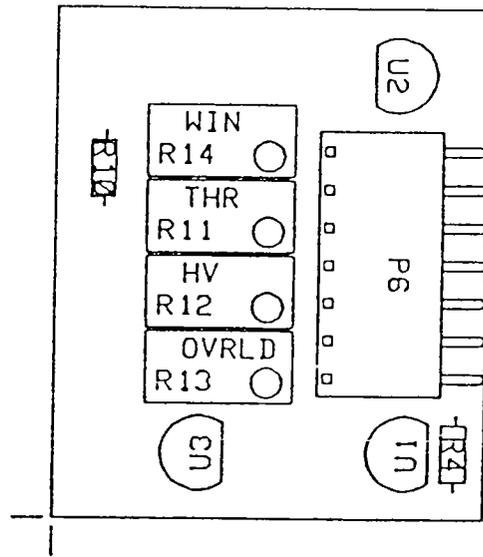
CONTRACT	LUOLUM MEASUREMENTS, INC.
PR CNB	8/15/81
CHK RDS	4/4/81
DSCL LL	8/17/83
APPD JGW	7/21/81
NEXT HIGHER ASST.	D 2221
18.23.1-9	83-15-31 A:SER81138.DRM
TITLE: PROCESSOR BOARD	BOARD# 8881-136
SIZE	MODEL
261	SHEET
91	SHEET
1	OF 1



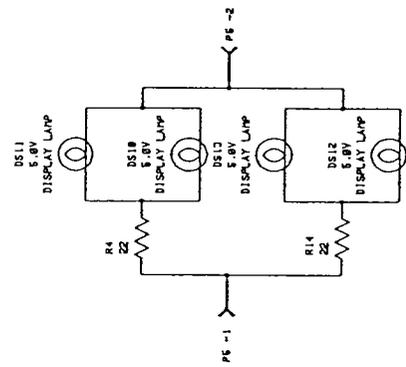
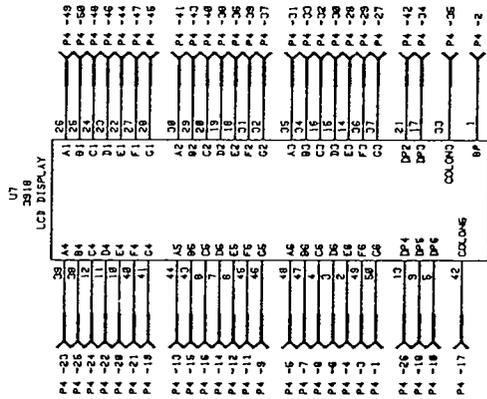
LUDLUM MEASUREMENTS, INC. SHEETWATER, TX.			
DR	CKB	02/15/91	TITLE: PROCESSOR BOARD
CHK	R.C.	4/13/98	BOARD# 5261-106 85261106
DSCN	LL	02/14/91	MODEL 2221 SERIES 261 SHEET 100
APP	B.S.	2/3/98	COMP ARTWORK <input type="checkbox"/> SLDR ARTWORK <input type="checkbox"/>
09:19:04	29-Mar-94	COMP OUTLINE <input type="checkbox"/> SLDR OUTLINE <input type="checkbox"/>	COMP PASTE <input type="checkbox"/> COMP MASK <input type="checkbox"/> SLDR PASTE <input type="checkbox"/> SLDR MASK <input type="checkbox"/>



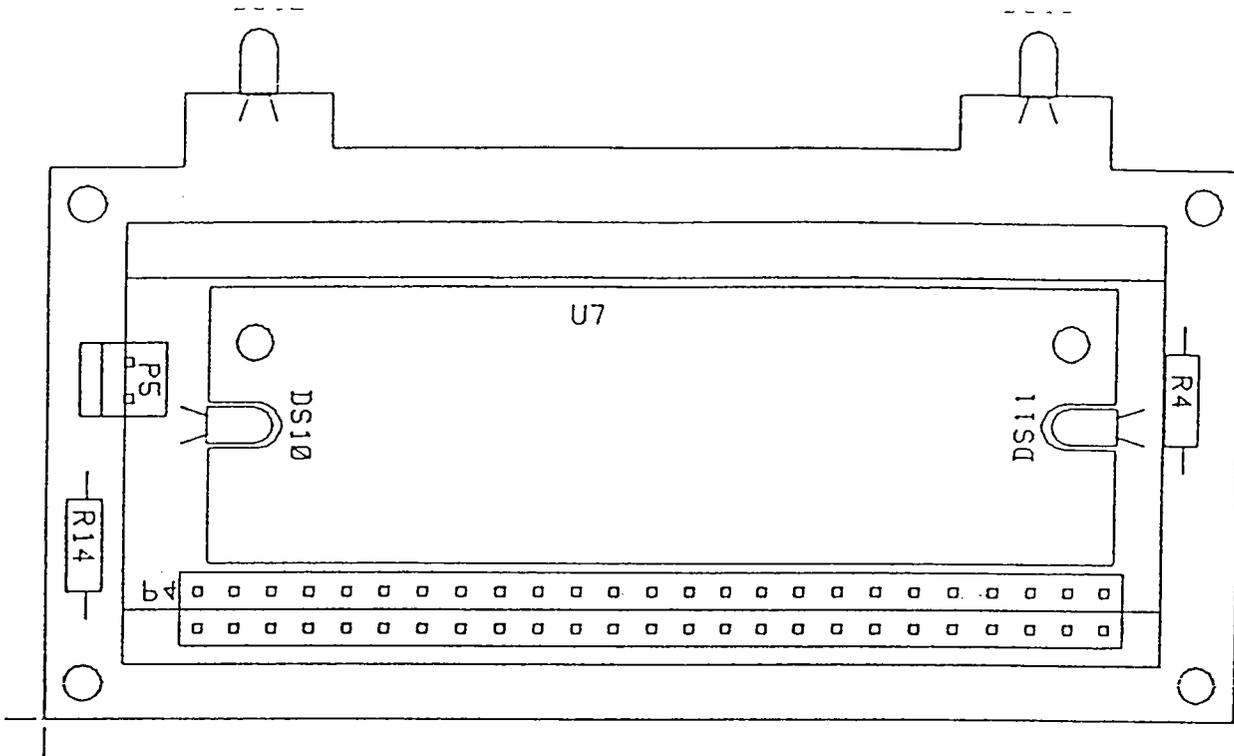
CONTRACT		LUDLUM MEASUREMENTS, INC.	
DR LL	3/16/88	TITLE: CALIBRATION BOARD	
CHK	R.C.	BOARD#	5261-075
DSGN LL	3/16/89	SIZE	D
APPD	DS	MODEL	221
NEXT HIGHER ASST.		SERIES	261
		SAFETY	59
			SHEET 1 OF 1



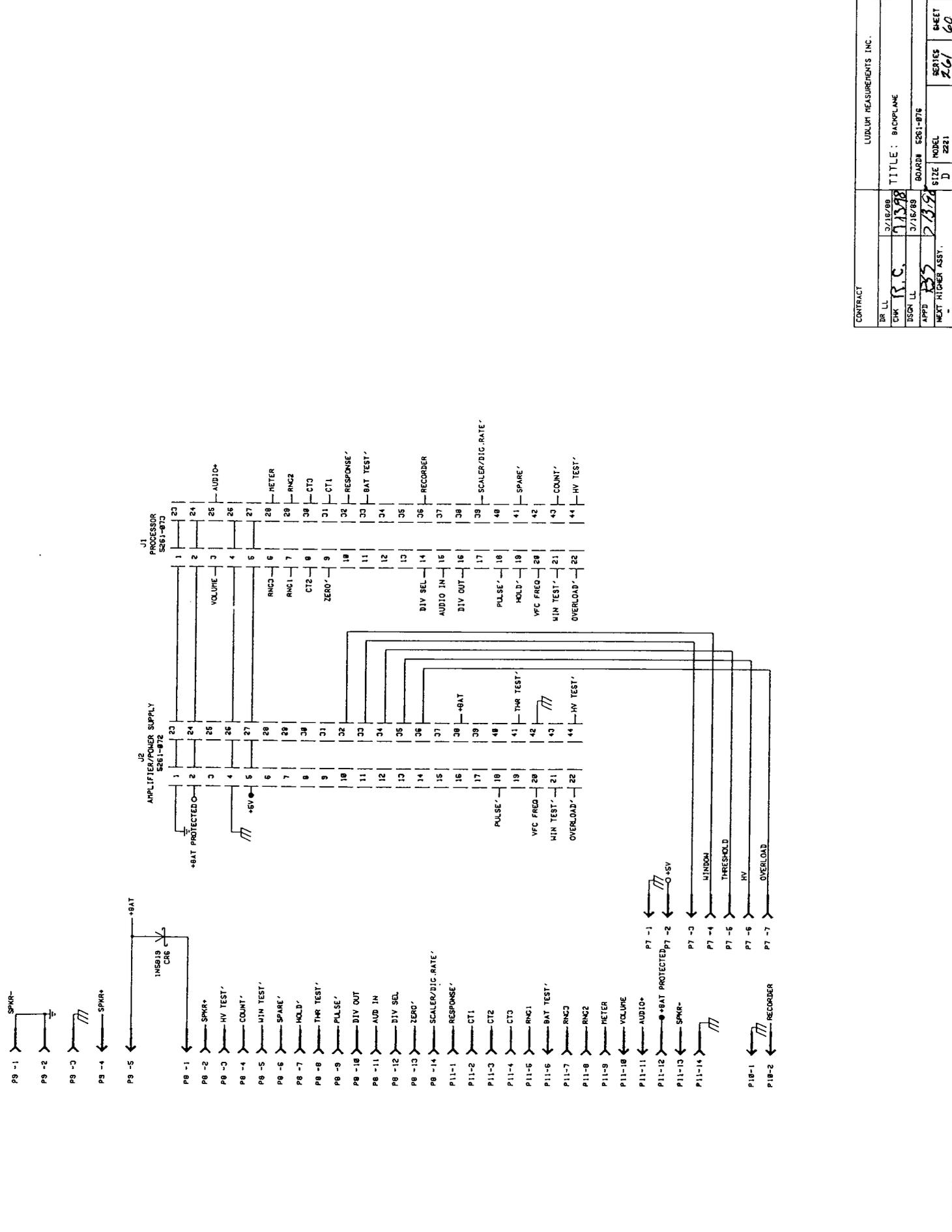
BOARD# 5261-075	
TITLE CAL BOARD	
MODEL 2221	
COMPONENT OUTLINES	
DR RDS	3/28/89
CHK R.C.	7 / 13 / 98
DSGN LL	3/16/89
APPD <i>RSS</i>	7 / 13 / 98
BS261075.DRW	
05-20-89	07:38:12



CONTRACT		LUDLUM MEASUREMENTS INC.	
DR LL	3/15/88	TITLE: LCD DISPLAY	
DAK	R.C.	7/3/88	
BOOK LL		3/15/88	
APP	BS	7/3/88	
REV	1000-ADIV.		
BOARD	ESSI-874	SIZE	D
MODEL	8811	QUANTITY	58
DATE	2/6/88	REV	2

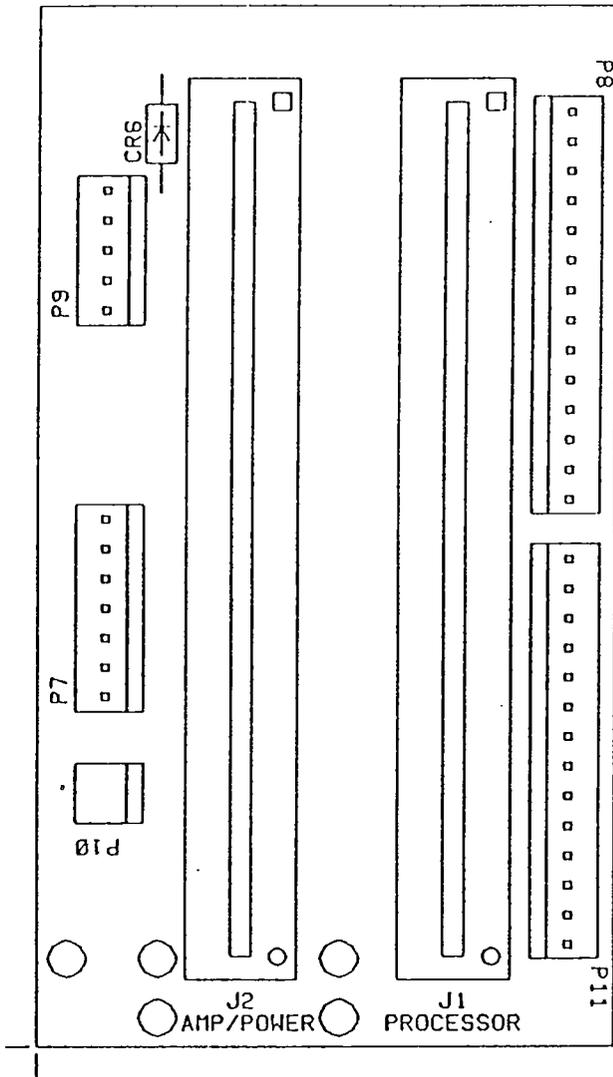


BOARD# 5261-074	
TITLE DISPLAY BOARD	
MODEL 2221	
COMPONENT OUTLINES	
DR -	3/27/89
CHK R.c.	7 / 13 / 98
DSGN LL	3/16/89
APP.D <i>RSS</i>	7 / 13 / 98
BS261074 .DRW	
05-24-89	15:44:20



CONTRACT LUDLUM MEASUREMENTS, INC.

DR LL 3/16/88
 CHK R.C. 7/13/88 TITLE: BACKPLANE
 DESG LL 3/16/88 BOARD 5261-072
 APPD B.S. 7/13/88 SIZE MODEL 221
 NEXT HIGHER ASSY. D
 85-24-80 5261/072.D04 SERIES 261 SHEET 60
 87:46:14 SHEET 1

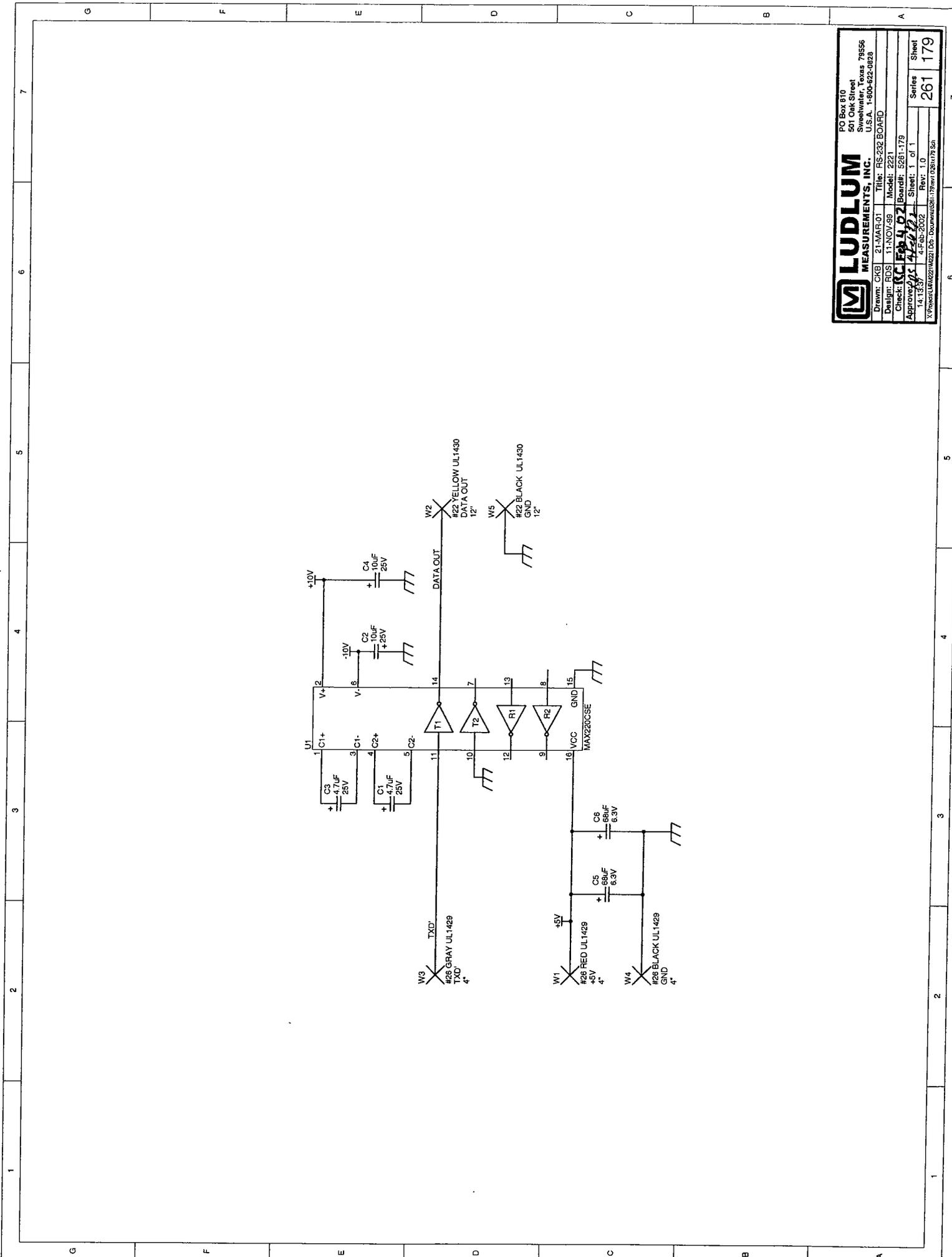
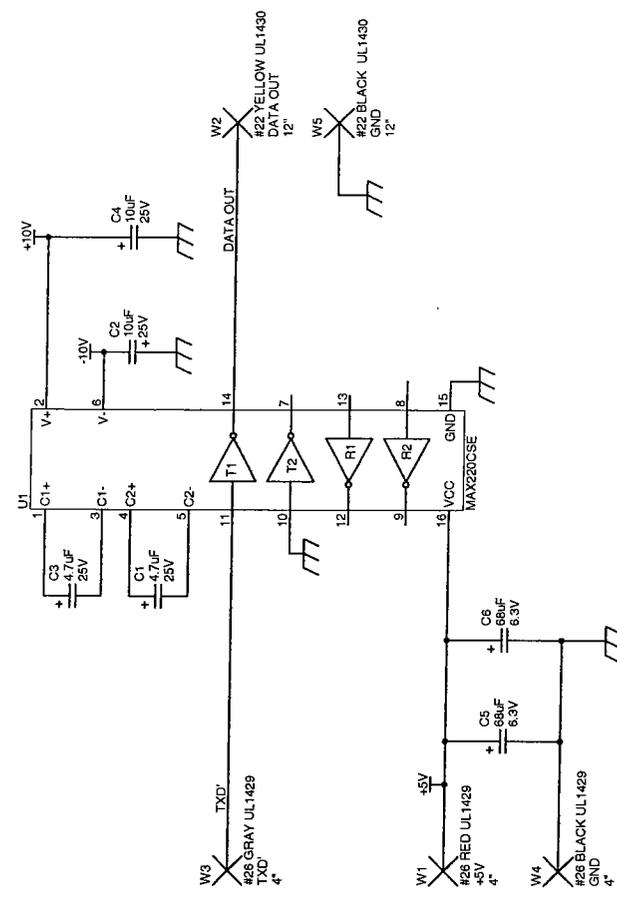


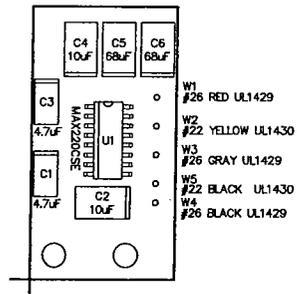
BOARD# 5261-076	
TITLE BACKPLANE	
MODEL 2221	
COMPONENT OUTLINES	
DR RDS	3/28/89
CHK R.C.	7/13/98
DSGN LL	3/16/89
APPD <i>RSS</i>	7/13/98
BS261076.DRW	
05-24-89	15:15:37

LUDLUM MEASUREMENTS, INC.
 PO Box 810
 501 Oak Street
 Sweetwater, Texas 79556
 U.S.A. 1-800-622-0828

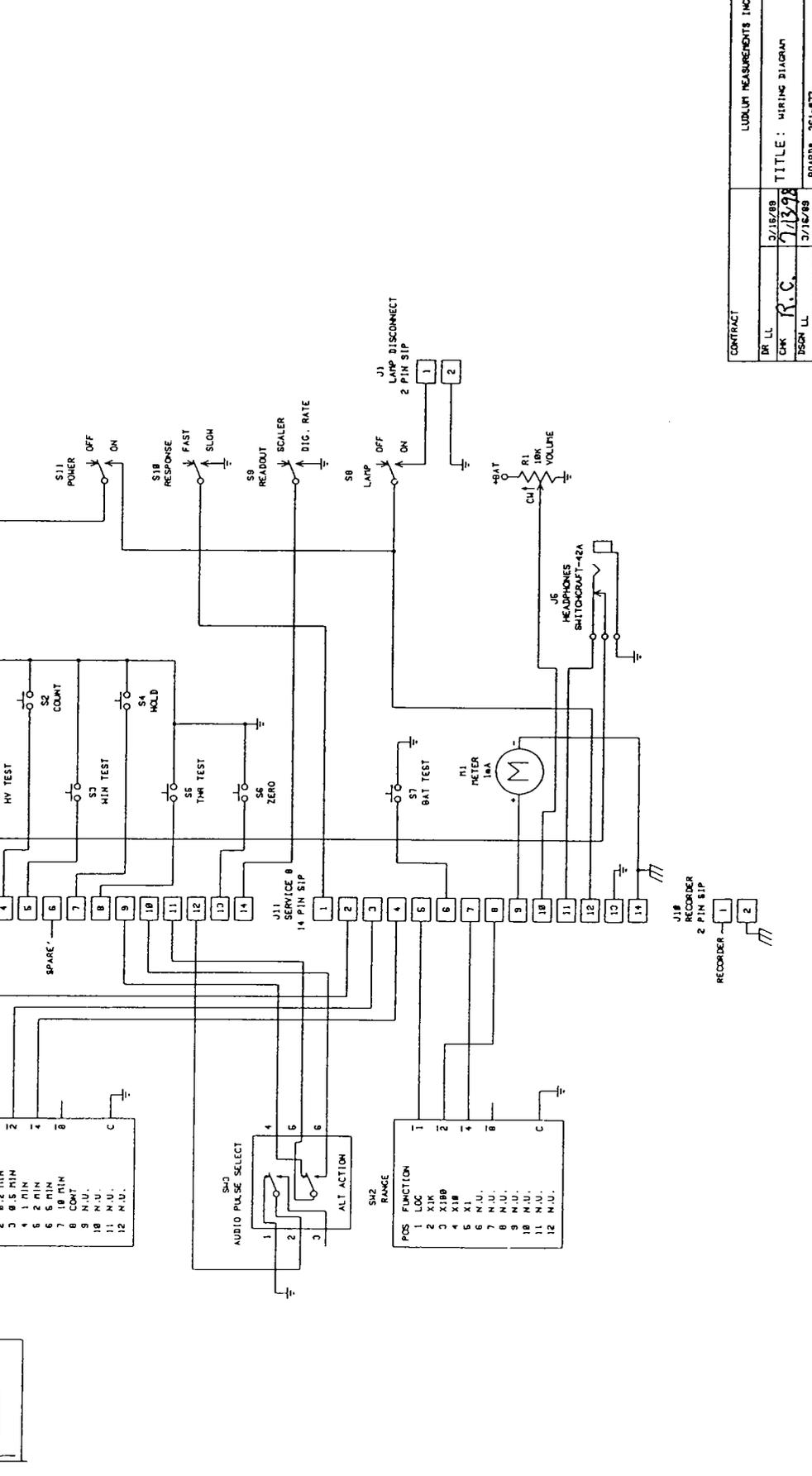
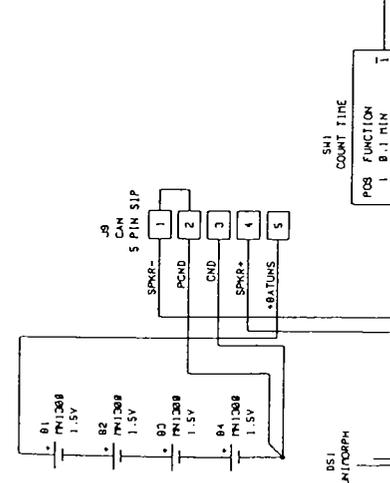
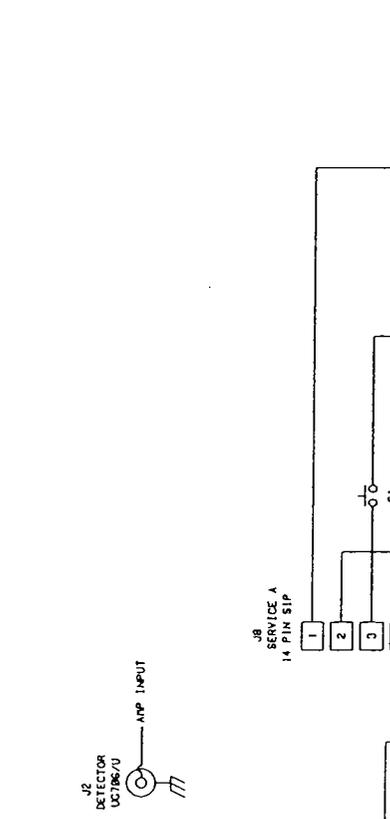
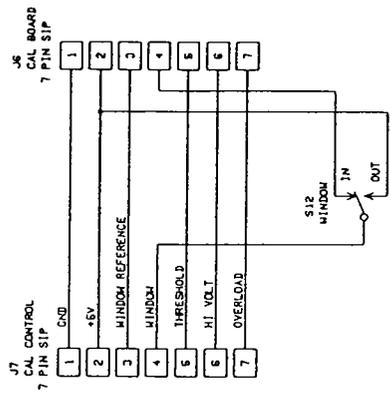
Drawn: CKBL 21-MAR-01 Title: RS-232 BOARD
 Design: RDS 11-NOV-99 Model: 2221
 Check: **SCF** 4/27/01 Board: 5261-179
 Approved: **SCF** 4/27/01 Sheet: 1 of 1
 14.1.2.37 4-Feb-2002 Rev: 1.0
 X:\Projects\ULM221\M221.Dwg. Doc: docname\5261-179\Rev1\CSM179.Sch

Sheet	261
Series	179





Drawn:	CKB	21-MAR-01	Title:		
Design:	RDS	11-NOV-99	RS-232 BOARD		
Check:	R.C.	Feb 4, 2002	Model: 2221		
Approve:	RDS	4 Feb 02	Board#: 5261-179		
Layer:	Top Overlay		Rev: 1.0	Series	
Mech,1	MD:		SCALE: 1.00	261	
Mech,2	14:02:28				180
Mech,3	4-Feb-2002				
Mech,4					



CONTRACT

LUDLUM MEASUREMENTS INC.

DR LL 3/16/88

CHK R.C. 7/13/88

TSON LL 3/16/88

APPD BSS 7/13/88

NEXT HIGHLY ASST.

BOARD 261-877

SIZE D

MODEL 2221

SHEET 61

85-28-88 38331877.000

17-31-88